Economic Analysis

Introduction

The objective of this section is to provide guidance to help functional proponents and project managers understand and develop an economic analysis in support of Class VI(a) and Class VI(b) systems. An economic analysis is performed when the range of the anticipated program cost is in the Class VI(b) range of $250,000 to $1,000,000 or in the Class VI(a) range of $1,000,000 to $2,500,000. An economic analysis supporting a Class VI(a) system requires additional analysis beyond what is required for the Class VI(b) system.

Definition

An economic analysis provides a systematic method for studying problems of choice. Alternative ways to satisfy a requirement are studied by evaluating the quantifiable costs and benefits of each alternative course of action. These costs are assessed objectively using economic techniques so that alternatives can be compared through a numerical ranking.

Purpose

An economic analysis is conducted to ensure the efficient allocation of scarce resources. An organization rarely has adequate funding resources for obtaining all of its needs to meet mission requirements. Thus, decision makers need economic evaluations to help them choose projects. Decision makers must be confident that the most economical and beneficial alternatives to meet a given need are considered in the decision making process. The most cost effective solution among many alternatives is identified and selected by performing an economic analysis.

Economic Analysis Versus Budgeting

Economic analysis and budgeting are completely separate processes. Economic analysis is used to help determine the most cost effective alternative to the government that meets an organization's requirement. Budget analysis provides an organization with the total cost impact of an alternative. Data presented in the economic analysis may or may not be useful in a future budget process. An economic analysis may contain costs over several organizations, making it difficult to use them in the budgeting process for a single organization. Other costs are omitted from the economic analysis because they are wash costs (the same for all alternatives).

Period of Analysis

In order to prepare an economic analysis, it is necessary to determine the number of years over which the alternatives will be compared. This time frame is known at the period of analysis. The period of analysis is the economic life of the selected system alternatives plus their lead time, or the period of time from the start year to the end of the economic life. If the period of analysis differs between the alternatives in the analysis, the alternative with the shortest period of analysis will determine the period of analysis for the economic comparison. The period of analysis begins with the first year in which costs are incurred. The parameters of the analysis period are defined below.

1. ***Start Year.*** The first year in which costs occur for a selected alternative. All costs in the economic analysis are estimated to reflect the price level of the start year.

2. ***Base Year.*** The reference year for all present value calculations. Base Year is usually the same as the start year.

3. ***Lead Time.*** The period of time between initial funding or decision and commencement of the economic life.

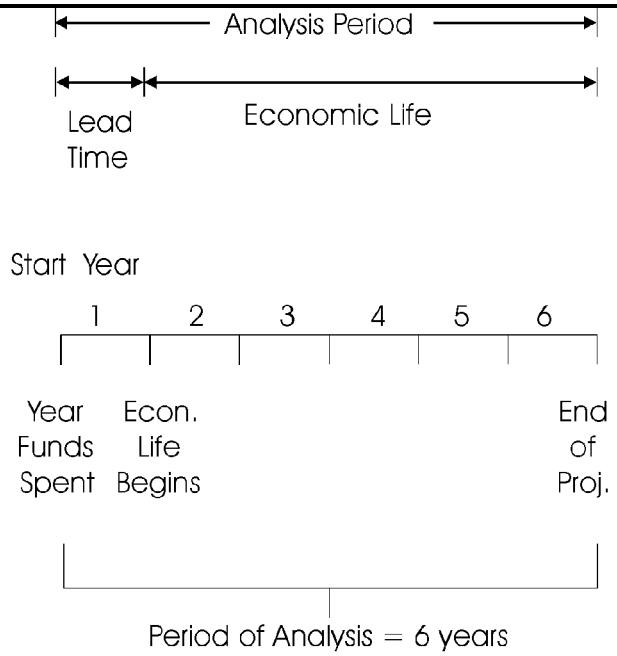
4. ***Economic Life.*** The period of time over which the benefits of the selected alternative are expected to accrue. The economic life of an alternative is often limited by the alternative's physical life (the

period of time over which the asset can operationally perform) or technological life (the period before the asset becomes technologically obsolete). In an economic analysis, the economic life of an AIS or program for Subclasses VI(a) and VI(b) projects is generally assumed to be five to seven years. The analyst should note that an AIS comprises various types of equipment, each with its own period of utility, or equipment life. Equipment life is the time during which the equipment of the system is operational without an undue number of repairs and while the vendor continues to provide support. Thus, equipment life does not always coincide with system's economic life. If the life of a certain piece of equipment in an AIS is shorter than the systems economic life, the analyst must include equipment replacement or upgrades to enable the system to function over its entire life.

Figure 3-1 depicts the relationships among the parameters in an economic analysis.

The Economic Analysis Process

Economic analysis development consists of seven basic steps. By following the seven steps process the analyst will be able to develop a complete and well documented economic analysis. The seven steps in the economic analysis process are shown in Figure 3-2. When preparing an economic analysis in support of a Class VI(b) system ($250,000 to $1,000,000) the comparison of alternatives need only provide a net present value (NPV) ranking of alternatives (Step 5) and Step 6, sensitivity analysis, is not necessary.



Relationships among key dates in an Budget Analysis.

Figure 3-1

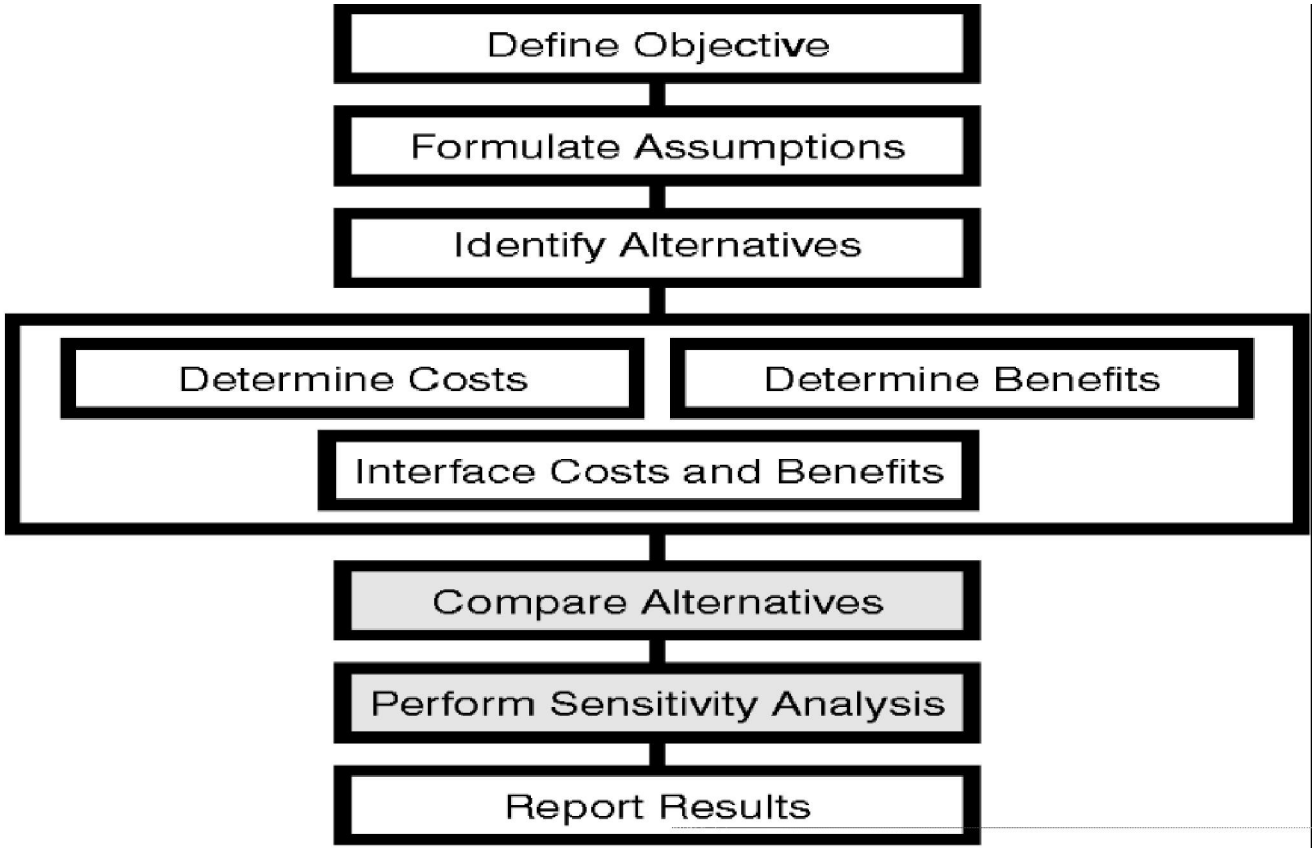


Figure 3-2

These steps have been modified for a Class VI(b) system since the program costs are below $1,000,000. When an economic analysis for a Class VI(a) system is being performed the analyst should perform all seven steps since the program costs are above $1,000,000 and represent major investments.

1. ***Define the Objective.*** The single most important step in an economic analysis is to define the objective. Without a clear, concise statement of what the economic analysis is to evaluate, the economic analysis will not be successful. With this definition, the analyst sets the objectivity of the analysis. An improperly stated objective may indicate that the economic analysis was done to justify a conclusion and not to determine, without bias, the most economical solution for a requirement.

The example at right illustrates how an objective can be correctly and incorrectly defined.

In this example, the correctly stated objective is in unbiased terms, while the incorrect one is biased towards purchasing a laser printer for each employee. Wording is critical in stating the objective. Not only should the objective be unbiased, it should also identify explicit criteria for measuring the results which can be applied to any solution. In the example, the standards are: 50 employees must have laser printing capability, the wait time must not be more

PROBLEM: Managers of the personnel office notice that the employees are always lining up at the three laser printers in the department, wasting valuable productivity time. They recognize that reasonable access to laser printing is a problem that must be solved.

CORRECTLY STATED OBJECTIVE: To provide laser printing capabilities to 24 employees. Capabilities should provide a wait time of no more than three minutes and allow users to continue working while waiting for documents to print.

INCORRECTLY STATED OBJECTIVE: The personnel office needs to provide each employee with a laser printer.

Table 3-1

Objective Checklist	Complete
Does the objective address the actual problem?	
Is the objective concise and understandable?	
Is the objective formulated in unbiased terms, without stating a specific solution?	
Are specific outputs or results of the requirement clearly described?	
Are explicit criteria for measuring the outputs for results clearly identified?	
Are the requirement and criteria realistic and achievable?	

than 3 minutes, and all employees must be able to continue to work while printing. Any proposed solution must satisfy the stated criteria, in order to be considered a viable alternative.

Table 3-1 provides a checklist to help the analyst define the objective of the program for an economic analysis.

2. ***Formulate Assumptions.*** An assumption is a statement describing unknown factors, data and circumstances that may affect the outcome of the analysis. Assumptions are used to describe the future environment when factual data about the environment are unknown. Often, analysts must formulate assumptions before they can choose alternatives wisely. Assumptions must be stated so that reviewers can assess their impact on the costs and benefits of each alternative. Assumptions must be realistic and logically consistent so that reasonable solutions are being considered, which in turn adds credibility to the analysis. Assumptions should never be used if factual data is available or can be obtained, since they may impact the validity of the analysis.

a. *Formulating Assumptions.* Formulating assumptions is an iterative process. As the analysis develops, information that was previously unknown will become available to the analyst. The assumptions of the analysis will change and, in turn, lead to refinements in the definition of alternatives. By recognizing this process as being evolutionary, the analyst can adapt and make appropriate adjustments. The result is a sounder and better prepared analysis.

b. *Types of Assumptions.* Assumptions can be made on general parameters which pertain to the entire analysis, or specific aspects of the analysis which apply only to certain alternatives. Some common assumptions include, but are not limited to:

- € the start and base years,
- € the economic life of a system or piece of equipment,
- € future costs,
- € system or program requirements,
- € time and schedule constraints,
- € physical constraints.

PROBLEM: Managers of the personnel office notice that the employees are always lining up at the three laser printers in the department, wasting valuable productivity time. They recognize that reasonable access to laser printing is a problem that must be solved.

OBJECTIVE: To provide laser printing capabilities to 24 employees. Capabilities should provide a wait time of no more than three minutes and allow users to continue working while waiting for documents to print.

ASSUMPTIONS:

1. The start year is 1999.
2. Lead time (period extending from the expenditure of funds to the completion of installation) is one year.
3. The economic life of the selected alternative is five years.
4. Printer use is expected to remain constant over the period of analysis.
5. Personnel and workload are expected to remain constant over the period of analysis.

The example above illustrates how assumptions are correctly formulated.

Table 3-2 provides a checklist to help the analyst formulate assumptions for any economic analysis.

3. ***Identify Alternatives.*** The next step is to list alternatives initially considered to meet the objective. This should include reasonable ways of achieving the objective. While all reasonable solutions to the problem should be identified, it may turn out that some can be rejected initially due to physical, legal, or other implementation constraints that may eliminate the need to incorporate the alternative from further analysis. Alternatives that are not feasible must be discussed in the documentation but need not be included in the cost comparison. An alternative is said to be feasible if it fully meets the stated objective. It is vital that all realistic options be considered and documented.

PROBLEM: Managers of the personnel office notice that the employees are always lining up at the three laser printers in the department, wasting valuable productivity time. They recognize that reasonable access to laser printing is a problem that must be solved.

PROJECT OBJECTIVE: To provide laser printing capabilities to 24 employees. Capabilities should provide a wait time of no more than three minutes and allow users to continue working while waiting for documents to print.

ALTERNATIVES CONSIDERED:

1. *STATUS QUO:* Currently, one PC has a laser printer connected to it. All employees must place their files on a diskette. When an employee wants to print a file they must go to the PC with the laser printer connected and print from there. This causes employees to wait in line to print their documents while others print theirs. Because this alternative does not satisfy all of the criteria, it is not feasible.

2. *3270 TERMINAL EMULATION:* Provides 3270 terminal emulation for personal computers (PCs). Users would then dial up the organization's mainframe to submit jobs, directing the output to the centrally located laser printer. The mainframe printer is located on the first floor and would cause employees to travel back and forth between the first and sixth floors several times daily to receive their print jobs.

3. *ONE-FOR-ONE CONNECTION:* Provides for a laser printer to be directly attached to every personal computer. This option is not feasible due to lack of space at individual work stations.

4. *LAN CONNECTION:* This alternative provides laser printer services to all of the employees' personal computers by sharing resources over a LAN. This solution allows the employees to continue working while waiting for documents to print. On average, wait time is approximately 2.5 minutes. Printers would be a shared resource, servicing the individual offices and user clusters of up to eight people. One PC in each cluster would act as the printer server.

Table 3-2

Assumptions Checklist	Complete
Has the economic life of the selected alternative been defined?	
Are the assumptions realistic and logically consistent?	
Is there any uncertainty that should be accounted for?	
Have policy and procedure limitations been considered?	
Have physical limitations been considered?	
Have time related considerations been identified?	
Can verifiable facts replace an assumption?	

Table 3-3

Assumptions Checklist	Complete
Have appropriate sources of information for identifying reasonable solutions been utilized and documented?	
Have reasonable alternatives satisfying the requirements stated in the objective been identified?	
Have all alternatives been checked against the measures of outputs or results outlined in the objective?	
Do the alternative descriptions show how measures of the outputs or results meet or fail the measures stated in the objective?	
Have the components and functions of the alternatives been clearly described without obscuring the narrative with too much detail?	
Has the alternative that best meets the requirements been selected?	

The preceding example illustrates the correct process of identifying alternatives for an economic analysis.

The example documents several alternatives, including the status quo. This shows the reviewer that different options to satisfy the requirement were considered, not just the chosen solution. Each alternative is described fully without being obscured by technical details and jargon. All the descriptions specify how the alternatives meet or fail the expected output and results.

Table 3-3 on the following page provides a checklist to help the analyst define and describe alternatives for the economic analysis.

4. ***Determine Costs and Benefits.*** All differential costs and benefits associated with the feasible alternatives should be included in the analysis. The source and calculation of each cost must be identified in the analysis as well.

a. *Determine Cost Categories.* Various financial analysis guidelines identify major cost categories and their sub-groupings. In addition to the Corps of Engineers, the Department of the Army and the Department of Defense continually review cost category structures to make analysis more meaningful and to reflect current acquisition strategies. There are elements associated with AIS acquisitions that constitute major cost drivers. These cost drivers basically remain the same, regardless of the structure mandated by the current applicable guideline, and can be categorized as nonrecurring and recurring.

Nonrecurring costs are costs that are paid one time. Examples include investment costs for hard ware and software, as well as one-time costs associated with investments such as site activation and initial training.

Recurring Costs are those paid on a periodic basis.

These are costs associated with operations and maintenance, and include such items as computer or other equipment maintenance, leases, and supplies.

Two special types of cost must also be discussed, but they are not included in the economic analysis. These special costs are referred to as washed and sunk costs. A wash cost is one that occurs identically for all alternatives. Wash costs can normally be excluded from the economic analysis since they will not affect alternative rankings or the Savings-to-Investment Ration (SIR). However, if the economic analysis results will be used to represent total discounted dollars needed or to be spent, wash costs should be included. A sunk cost is one that will occur before the period of analysis. Sunk costs are past history. They will have no bearing on the future and are therefore disregarded in the economic analysis.

Listed below are the major cost elements considered when conducting financial analyses of Subclass VI resource acquisitions. They are categorized as Investment (Nonrecurring) and Operations (Recurring). A complete list of authorized DA cost elements required for MAISRC-level financial analyses are provided in Appendix B.

INVESTMENT (**NONRECURRING) COSTS**
- Project Management
- Hardware
- Software
- Documentation
- Initial Training
- Site Activation
- Test and Evaluation
- Parallel Operations

OPERATIONS **(RECURRING)** COSTS
- Supplies
- Operations
- Maintenance
- Leases

b. *Gather Cost Data.*

1) The first activity in gathering data is to think of what data is needed for each cost element. Table 3-4 discusses important points to consider when gathering data.

2) The second step in gathering data is to identify sources for each cost element and their component costs. The following examples provide data sources for various types of information.

Government Publications: The General Services Administration (GSA) price lists can be used to determine the costs of commonly requested hardware and software available at government rates. The government pay scale can be used to develop labor costs for various systems support functions. Pay rates are determined by the civilian employee's Grade and Step (GS) level. When developing cost estimates, a median rate (Step 5) is assumed within each grade.

U.S. Army Information Systems Command Resource Factors Handbook (USAISC Pamphlet No. 11-2) provides details on the costing of elements, including civilian and military pay, hardware and software, telecommunications, and other operating and support costs.

Professional Publications: Publications such as DataPro are recognized authorities on hardware and software. These publications contain an industry-wide surveys on computer products, detailed technical specifications, and performance comparisons. The publications contain vendor prices and associated equipment costs such as installation and maintenance fees. This type of professional publication can be very useful to determine alternative solutions to improve system operations (see Step 3: Identify Alternatives).

Other professional publications include industry magazines such as Info World, PC Week, and distributor catalogs such as Black Box Catalog. These publications typically contain less detailed information than DataPro, though they are useful for determining costs for a variety of

computer products.

Contracts: Vendor contracts provide specific information on products and services over the life of the contract. Current contracts are especially useful since they contain the precise cost information used for recently procured hardware, software and technical services.

Expired contracts are also useful because they contain historical data that can be extrapolated into the present or future. For example, historical contract prices can be used to project, using inflation, the current costs of products and services. Cost estimates should be adjusted for product comparability and normal price increases.

Cost information can be obtained from contracts held by the Corps of Engineers as well as from other government agencies.

Budget and Financial Reports: Budget reports provide information on planned funding limitations. Financial reports contain data on expenditures and are particularly useful for trend analysis and extrapolating future costs.

Site-specific Information: Site-specific information can be obtained through questionnaires or interviews. This type of data is valuable because it is obtained at the source. Frequently, financial reports provide information that has been summarized, so that individual line item costs are indeterminate. Site-specific data can be gathered with the appropriate level of detail required to adequately support the analysis. This information also provides the analyst

Table 3-4

COST ELEMENT	CONSIDERATIONS
Nonrecurring Costs (One Time Costs)	
1. Project Management	€ Is a special project team required? € How is the project management team made up? Grade levels? € Are there contractors supporting the project management office? € What are the expected annual contractor costs? € Will travel be required by the project team?
2. Hardware	€ Will any new hardware be needed, including CPUs, file servers, and peripherals such as printers? € What is the new hardware configuration? € Is there a contract vehicle for purchasing the hardware? € When will the hardware be upgraded? € What communications equipment is needed? € Will existing modems be used?
3. Software	€ Will the hardware require any new operating software? € What new commercial-off-the-shelf (COTS) or proprietary software will be needed? € When will the software be upgraded? € Will any new application software be required? € What is the estimated time to complete the software development? At what level? Contractors? In-house development? € Any data conversion needed (e.g., from manual to automated, or from system to system)? € What communications software is required?
4. Documentation	€ Will hardware or software technical manuals be required? € Will user manuals be required? € Will manuals be off-the-shelf or developed? € How many manuals are required? At what per unit cost?
5. Initial Training	€ Will training be required? If so, how much? € How many people will be trained? € Will people be trained in a classroom setting? With computer-based instruction? € Is travel required for the training? Per diem?

Table 3-4 (continued)

COST ELEMENT	CONSIDERATIONS
6. Site Activation	€ Will a site survey be required? Who will do the survey? At what GS level or contractor rate? € Will facility modifications or upgrades be required before the system can be installed? € Will additional communications capabilities need to be installed for for the system? Dedicated circuits? Dial-up circuits? What line speed?
7. Test and Evaluation	€ Will testing and evaluation be required? € When and where will it occur? € Will it be completed by in-house or contractor personnel? At what GS level or contractor rate?
8. Parallel Operations	€ Will the current system be maintained while the new system is implemented? For how long? € Who will operate the current system while the new one is being implemented? Government or contractor personnel? € At what GS levels or hourly contractor rates?
Recurring Costs	
1. Supplies	€ What paper products are needed? € What hardware and software products will be required? Tapes? Floppy diskettes?
2. Operations	€ How many people will participate in supporting/operating the system? € Will operators be government personnel or contractors? € What are the GS levels or hourly contractor rates? € What will be the costs for utilizing outside service bureaus, if any (especially under “Status Quo”)?
3. Maintenance	€ What is the warranty period for hardware? € What is the warranty period for software? € What are the annual hardware maintenance charges? € What are the annual software maintenance charges?
4. Leases	€ Will any of the hardware or software be leased? What are the annual costs? € Will any communications equipment or lines be leased? What are the annual costs?

with an excellent view of how operations are performed in the current environment.

Project Manager's Office: The Project Manager's Office (PMO) can supply guidance on what assumptions should be made in the analysis. For example, the Project Manager makes the decisions about what training should be conducted, what personnel will be trained, etc; whether or not site surveys are required and how they should be performed; and what configurations of hardware and software will ultimately be installed.

3) The third activity in gathering data is to collect the information from sources based on the stated objective and assumptions. For example, after the hardware/software configurations for each alternative are determined, the analyst should consult government contracts, conduct telephone surveys, and research DataPro for information on the pricing, installation, and maintenance of the products. It is important to check multiple sources to ensure that both high and low cost estimates are considered. As a general rule, cost estimates should be realistic and conservative.

c. *Gathering Benefits Data.* The main benefit to be derived from an AIS is fulfillment of the stated objective. This is a benefit common to all alternatives in the economic analysis, and its inclusion in the economic analysis calculations would not affect the ranking of the alternatives. So, dollar quantification of the major benefit is unnecessary. Emphasis is therefore placed on the costs of the alternatives. If dollar exist quantifiable benefits (other than meeting the stated objective) for an alternative, they are treated as cost offsets for that alternative.

d. *Cost Estimation Methods.*

1) Perhaps the most difficult phase of an economic analysis is the estimation of costs. However, this part of the economic analysis is crucial because the results will only be defendable to the extent that the cost estimates are reliable. Estimates can never be 100 percent precise as they are made several years before the costs will actually occur. Estimates must be as precise as possible given the constraints on the analyst in performing the economic analysis. Precision is usually obtained by acquiring as much detailed data as possible. Most cost estimates are based on historical data.

2) The analyst chooses the proper level of detail and accuracy in the estimates. These must be weighed with the time allowed to obtain the estimates. Detail and accuracy can be of three levels:

a) *Order of magnitude estimates.* The accuracy of these estimates is very low and can differ from the actual cost by as much as 50 percent. These are used when there is not enough time, funds, or both to do a detailed estimate or when the magnitude of the cost is so small that large inaccuracies will not be a determining factor in the analysis.

b) *Good estimates.* Good estimates are those for which accuracy is within 10 percent of the actual cost.

c) *Detailed estimates.* These estimates will normally be within 5 percent of the actual costs. They are often derived from detailed plans or from accurate historical records. These estimates should be used when possible to ensure the validity of the analysis.

Cost estimates must be made with care and with full knowledge of their limitations. The limitations (assumptions) must be fully documented in the economic analysis re-

port.

e. *Constant Dollars and Inflation*. Inflation is the rise in costs (or prices) of goods and services over time. In an economic analysis, inflation is generally not applied to the costs of the alternatives.

1) *Constant Dollars*. The economic analysis should be done using constant dollars, where costs do not include inflation. The use of constant dollars indicates constant purchasing power in terms of the dollar value of the start year. Thus, all costs for each alternative reflect the level of prices for the start year.

2) *Use of Inflation.* In most economic analyses inflation will not be a problem. There may be times, though, when the analyst will have to inflate or deflate certain costs. For example, if cost estimates are obtained in 1997 prices, but the start year of the analysis is not until 1999 inflation must be applied to change 1997 dollars into 1999 dollars. Current inflation rates can be found in Appendix D.

5. ***Compare costs and benefits.*** This step is the heart of the analysis. It is also the easiest, because once the first four steps have been completed, the comparisons and ranking can be done using computer programs. Comparisons give managers the information needed to make informed decisions. Once the costs and benefits for all options are found, one option can be compared with another. The general criterion used to compare and rank alternatives is net present value (NPV), which determines the least cost solution for a given level of effectiveness.

Economic analysis alternatives are compared and ranked using present values of costs and benefits. The concept of time value of money is fundamental to economic analysis and must be understood before other aspects of the analysis can be discussed. The value of $1,000 today is not the same as $1,000 five years from now. Money is a productive commodity and there is a price for its use. This price is called interest. Interest is expressed as a percent or decimal representing the fractional amount of a loan the borrower must pay the lender within a specified interval of time.

a. *Present Value and Discounting*

1) *Compound interest.* Suppose an amount of money, P, is borrowed today at an annual interest rate, i. The amount of money, P, is called the principal. Assume that the money is to be repaid at the end of 1 year. At that time, the borrower will have to pay the lender not only the principal, P, but an additional amount, (P x i). This surcharge, P(i), is the price (interest) the borrower must pay for the use of the money for the year that the loan is outstanding. So, the total future amount, F1, paid to the lender is:

$$F1 = P + Pi = P(1 + i) \quad \text{(Equation 1)}$$

Now suppose the above loan is to be repaid at the end of 2 years instead of 1 year. The amount which would have been repaid at the end of year 1 is P(1 + i), as shown in equation 1. This becomes the principal during the second year; that is, the interest has been compounded at the end of year 1. The amount repaid at the end of year 2 is:

$$F2 = P(1 + i) + [P(1 + i)]^{i}$$
$$= P(1 + i)(1 + i) = P(1 + i)^2 \quad \text{(Equation 2)}$$

In equation 2, P(1 + i) takes the place of P in equation 1. To compute compound interest for, n, years, the same reasoning is used. The general equation for the total amount to be repaid to a lender at the end of, n, years for an amount, P, loaned today at an annual rate of interest, i, is:

$Fn = p(1 + i)^n$ (Equation 3)

Another way of viewing this loan is that the future value to the lender of, P, dollars today is $P(l + i)^n$ dollars, n, years from today. The borrower, in order to secure, P, dollars today, is willing to pay P(1 + i)n dollars n years from today. The lender and borrower complement each other as, P, dollars today and

P(1 + i)n dollars n years from now are equivalent. Using equation 3, any principal amount can be converted to a future value.

2) *Discounting.* The reverse is also true. Rearranging the equation, any future amount can be converted to its present value. If the principal, P, in equation 3 is viewed as the present value (PV) of the future amount Fn, the relationship can be expressed as:

$$PV = Fn \frac{1}{(1 + i)^n} \quad \text{(Equation 4)}$$

In equation 4, Fn represents the dollar amount value, n, years in the future of an investment today at an interest rate, i. The PV represents a cash equivalent in today's dollars (that is, a present value or present worth). The quantity $1/(1 + i)^n$, which is a number less than one, reduces the future cash amount, Fn, to its equivalent PV, and is called a discount factor.

The Army is no different from a private investor that seeks the best return on its investments. In Army economic analyses, future costs and benefits are brought to a common point in time so that valid comparisons can be made.

In equation 4 the value of i is called the discount rate. This rate is established by the Office of Management and Budget (OMB). The method used to determine the discount rate for DOD capital investments is described in OMB Circular A 94, and can be found in Appendix C which is updated annually. It proposes that the discount rate for government investment analysis be tied to the rate at which the Federal Government is willing to borrow money.

3) *Discounting Factor.* Timing of costs is important in an economic analysis. So, the discount rate is different based on when the costs occur; end of year or mid year. End of year means that the cost or benefit occurs at the end of a year whereas mid year factors are used for costs and benefits occurring in the middle of the year. If they occur evenly during the year, it is customary to use the total for the year and use a mid year factor. Equation 4 is used to calculate both end of year and mid year factors. As an example, to calculate the end of year factor for 10 years, simply use 1 for, Fn, and 10 for the value of n; to calculate the mid year for 10 years, use 9.5 for the value of n.

4) *Summary.* Money is a productive commodity and as such commands a premium, called interest, for its use. Because of this, there is a time value associated with money. A dollar today is worth more than a dollar 5 or 10 years from now. (A dollar today can be invested and earn interest.) Investors take this fact into account when analyzing an investment proposal involving expenditures and receipts at varying points in time. To make meaningful comparisons, costs and benefits must be converted into equivalent costs and benefits occurring at a single point in time. This point is usually the present or the time of analysis. Equation 4 is used to convert future values to that time.

b. *Methods of Economic Analysis*

1) *General.* This chapter describes five economic analysis methods used to compare alternatives. Each method includes examples of how and when to use it. For a Class VI(b) system the only method that should be used to rank alternatives is net present value (NPV). In addition to net present value, other methods can also be calculated to help support economic analyses

performed for Class VI(a) systems. Other available methods are discussed below, **but net present value must always be calculated** for both Class VI(b) and VI(a) systems.

2) *Net present value (NPV).* This method is used when all alternatives meet the mission requirement over the same period of analysis. This method is the standard way to compare alternatives in the Army. It is the only method recognized by OMB Circular A 94 for economic analyses. NPV is calculated for each alternative. The alternatives are ranked and the one with the lowest NPV is the preferred option. The NPV is calculated for an alternative by discounting the value of the costs minus the benefits for each year and summing over the years for a total or net value.

3) *Savings/investment ratio (SIR).* Economic analysis finds the most economical way to meet a requirement, given that there is more than one alternative. However, there is the possibility a given requirement may already be met at the present time, but a better solution could be found. In the context of economic analysis, better specifically means that the total NPV cost of an alternative is lower than that of the existing alternative (the status quo) over the same period (economic life). In such a case, the justification for implementing another alternative is economic; the analysis supporting the proposal is called a primary economic analysis.

In addition to comparing a proposed alternative with the status quo by examining the total NPV costs, another method is used for primary analyses the savings/investment ratio (SIR). SIRs compare the profit potentials of the alternatives. SIR means exactly what it states the ratio of savings resulting from an alternative (to the present method) to the investment required for implementing the new alternative. An SIR value of 1.0 means that the savings NPV equals the investment cost NPV required to effect those savings. Thus, for an investment to be economically feasible, the SIR must be greater than one.

If there are several alternative(s), their SIRs can be compared (ranked). However, the analyst must assess other implications of the analysis such as amount of the investment and the savings. For example, one alternative might have an SIR of 5.0 while another has an SIR of only 2.0. Normally, the one with the higher SIR would be preferred. But if the total savings over the analysis period for the option with the higher SIR is very small in total discounted dollars compared with the savings from the other option, the one with the smaller SIR may be preferred.

The SIR is used only to compare investment costs to savings to determine if the investment costs can be recovered through savings.

When computing an SIR, total annual maintenance and operations are not discounted, only the difference between annual costs for the two alternatives. The crucial question is: Are the recurring savings of the alternative relative to the status quo enough to justify the investment costs needed to implement the alternative.

For an alternative A to a status quo Q, the total PV savings of A relative to Q can be calculated by equation 5.

$$PV(S) = PV(A1\ Q1) + PV(A2\ Q2) + \ldots + PV(An\ Qn) \qquad \text{(Equation 5)}$$

where S is savings, PV is present value of, I is investment, and Ai and Qi are yearly costs. Thus, the SIR is as shown in equation 6.

$$SIR = \frac{PV(S)}{I} \qquad \text{(Equation 6)}$$

If the investment extends over more than 1 year, it should also be discounted as in equation 7.

$$SIR = \frac{PV(S)}{PV(I)} \quad \text{(Equation 7)}$$

4) *Discounted payback period (DPP).* An easily understood method of comparing alternative investments or for evaluating a single investment is "payback analysis." Payback period is the time required for the total accumulated savings or benefits of a project to offset investment costs. So, if a project cost $100 and yielded annual savings of $25, its undiscounted payback period would be 4 years. DPP is often used in conjunction with the SIR. If the SIR is greater than 1.0, indicating the project pays for itself, the question then becomes "How long does it take to recoup the investment costs." DPP, like SIR, is used with the NPV as an aid in selecting the best alternative.

   a) Duration of project life has no effect on the payback period. For example, a payback period of 10 years has the same meaning whether the economic life is 15 or 25 years. Thus, the payback period can be used to help rank alternatives. Options with quick payback are generally preferred.

   b) The time value of money must be considered in payback computations. So, all costs must be discounted to compute a DPP. Payback is achieved when total accumulated PV savings are enough to offset the total PV costs of an alternative. The payback period is simply the total time between the point when savings begin to accrue and the point at which payback occurs.

5) *Benefit/Cost Ratio (BCR).* A complete economic analysis will identify and quantify all relevant costs and benefits of each alternative. Both costs and benefits expected for each alternative will be considered.

"Benefits" is an overall term for returns (savings, outputs, products, or yields). The benefits of each alternative must be expressed so that the decision-maker can make valid comparisons. This step is done using the benefit/cost ratio (BCR) method. In general the BCR is expressed as shown in equation 8.

$$BCR = \frac{\text{NPV of Benefits}}{\text{NPV of Costs}} \quad \text{(Equation 8)}$$

Benefits are measured in dollars. Total benefits relative to total costs are measured. The larger the BCR, the more cost effective the alternative.

   a) *Benefit types.* In general, four types of benefits are potentially associated with AIS projects. These benefits are not mutually exclusive. They include:

      (1) Direct cost savings.
      (2) Efficiency/productivity increases.
      (3) Nonquantifiable output measures.

   b) *Direct cost savings.* When direct cost savings are the main reason for performing an economic analysis, a primary economic analysis is usually done. The key aspect is that savings accrue, usually in the form of a reduction in recurring O&M costs. That is, after an initial investment, the funding level needed for the facility and its function will be reduced in future years. When the NPV of these savings exceeds the investment, the project pays for itself over its economic life and is self amortizing. A primary economic analysis is performed for such projects. The self amortizing is demonstrated by an SIR greater than one.

   c) *Efficiency/productivity increase ratio*

(EPIR). Often automation projects increase an operation's efficiency or productivity. These increases are very beneficial and should be included in the BCR analysis when they exist. Benefits of this type are often confused with direct cost savings because they are easy to quantify in dollar terms. However, they are not equal, and the analyst should understand the basic difference.

An increase in efficiency or productivity implies only one result: the ability to do more work within the existing manpower and funding levels. One way to translate an efficiency/productivity increase into direct cost savings is to effect a reduction in force (RIF) which lowers the required personnel funding level. The other way is to use the same manpower level to meet an increased workload requirement. A RIF is not usually intended as one of the required results and thus some other means of quantifying efficiency/productivity benefits must be used.

An efficiency/productivity increase that translates into a labor/time savings of 2 man years is a benefit whose value can be defined as what it would cost the Army to pay for an additional 2 man years of labor. This cost should be accelerated by the appropriate rates for leave and fringe benefits because the value of the benefit should reflect the actual total cost to the Army of providing 2 man years of work.

One very important policy must be mentioned at this point. To claim an efficiency/productivity increase as a valid benefit, there must be a documented need for the increased work load capacity. In other words, there must be an alternative use to which the manpower resources now available can be applied, such as reducing a backlog of maintenance. Without this justification, there is no quantifiable benefit derived from the project.

d) *Nonquantifiable output measures.* It is not always possible to quantify some benefits such as improved morale, and other qualitative benefits. However, they should be documented in the economic analysis report for consideration by the decision-makers. These written qualitative benefit descriptions can make a positive contribution to the economic analysis. Statements on qualitative benefits should follow these guidelines.

1) Identify all benefits associated with each alternative and give complete details.

2) Identify benefits common in kind but not in extent or degree among alternatives, and explain the differences.

3) Avoid platitudes. For example, all prospective projects are worthwhile because they support national defense, and statements to this effect are not needed.

4) Display the benefits in tabular form as shown in Table 3-5.

Table 3-5

Matrix of Benefits

	Increased Morale	Safety	Work Quality
Alt A	Yes	Same	Better
Alt B	No	Same	Same

6) *Summary.* This paragraph has outlined methods that can be used to evaluate and portray benefits in a benefit/cost analysis framework. These methods are not exhaustive, but illustrate approaches the analyst can take to evaluate the benefits of different options. Analysts should use these methods in addition to any others they find appropriate. If a unique method is used, the analyst should clearly and completely explain, justify, and document it for the economic analysis report. Negative aspects of an alternative should also be reported and quantified when possible. This information is important to the decision maker and may be a determining factor in selecting an alternative.

7) *Methods.* The methods described can be used to perform economic analyses for all automated information systems. Some methods work better for certain combinations of costs and alternatives than others. Once an analyst has done several economic analyses, selection of the method(s) will become second nature.

6. ***Perform Sensitivity Analysis.*** A sensitivity analysis is a "what" if exercise. It tests whether the conclusion of an economic analysis will change if some variable such as a cost, benefit, or discount rate changes. This step should only be performed when you are comparing alternatives in a Class VI(a) system (program cost of $1,000,000 to $2,500,000).

a. Sensitivity analyses should always be performed for a Class VI(a) system when:

1) The results of the economic analysis do not clearly favor any one alternative.

2) There is a great deal of uncertainty about a cost, benefit, or assumption in the economic analysis.

3) If a change in a variable or assumption causes a change in the ranking of alternatives, the economic analysis is said to be "sensitive" to that variable or assumption. By performing a sensitivity analysis and including its results in the report, the analyst ensures the decision maker that uncertainties in the economic analysis have been tested and the results documented.

b. Once all costs and benefits have been estimated, the analysis can be performed and the alternatives ranked to show which is economically best. However, the analysis is not complete until it has been examined for areas of uncertainty. Sensitivity analyses are used to evaluate the effect of these uncertainties on the ranking of the alternatives.

1) Some uncertainty is always present in economic decision making and, thus, some type of sensitivity analysis must normally be done in an economic analysis. In an economic analysis, future costs are predicted and there is an element of uncertainty about these data. Even if actual cost data from past projects are used, it is assumed that these data are an accurate estimate of future costs. Thus, all data used in calculating life cycle costs are actually based on assumptions. The sensitivity of an analysis is tested by evaluating a range of estimates for critical cost elements. The sensitivity analysis measures the percent change in one or more elements of an economic comparison that will reorder the ranking of alternatives.

2) No single criterion can be used to select the most important parameter or factor to be considered in sensitivity analysis. Each analysis has its own set of costs and assumptions.

3) A general rule when considering cost data is to examine the input variables. Variables that significantly impact the total NPV or the benefits of an alternative are good candidates for sensitivity analysis. An easy way to find these variables is to examine the percentage values of the present value of each cost against the net present value of the alternative. A rule of thumb is to examine all costs which are 20

percent or more of the total NPV for an alternative.

4) A sensitivity analysis is developed by asking the question: which input variables should be tested? That is, are there dominant costs with uncertainties concerning their magnitudes or their times of occurrence? Assumptions and constraints must be examined to determine if their variation affects the input variables.

5) As in the entire economic analysis process, the analyst should use common sense in deciding which sensitivity analyses to perform. If the ranking of alternatives shows that one is much less costly than the others, it is probably not necessary to evaluate small changes in costs that have no chance of reversing the ranking. It is when the magnitude or timing of a cost may affect the ranking or when the economic choice is not clear cut that further investigation is needed. There is no formal theory for performing sensitivity analyses.

6) The analyst should not make the sensitivity analysis too complex, as interpretation can be very difficult. A good guide is to study only two alternatives at a time and vary the uncertain costs within each alternative in the same way (an increase or decrease).

7) The analyst should have a range of values of the uncertainty in mind before doing the sensitivity analysis. For example, the uncertainty should be envisioned as ranging from 50 to 150 percent of the estimate or, say, from 70 to 100 percent of the estimate.

7. ***Report Results and Recommendations.*** Upon completion of the economic analysis, the results must be communicated to the decision makers in an easily understood format. The report should contain summary data for the life cycle cost analysis of each alternative, appropriate graphs, and summaries of any sensitivity analyses. In addition, it should present conclusions and recommendations. A complete report will contain all of these elements.

a. *Executive summary.* The first section of the report should be an executive summary. This section gives the objective, alternatives considered (feasible and nonfeasible), ranking of alternatives, conclusions, and recommendations. It also lists any assumptions made for the analysis. It gives some details such as the discount rate, period of analysis, and start and base years.

b. *Detailed life cycle cost analysis.* This section presents tables of detailed costs for each alternative in each year of the analysis. These tables show the occurrences and patterns of costs over time for each alternative. The sources and derivations for costs are also given in this section.

c. *Graph of NPVs.* A graph showing cumulative NPV for each alternative over time should be included.

d. *Sensitivity analysis.* This section should begin with a paragraph discussing which costs need to be examined in sensitivity analyses. Then results of varying these costs effects on the alternatives' rankings are given.

e. *Source Derivation.* This section should provide a description, calculation, and source for all costs included in the economic analysis. This is very important as an audit trail to the analysis.

ECONPACK Computer Program For Economic Analysis

1. Proper preparation of an economic analysis requires a major effort to gather data, do mathematical calculations, and summarize results into required report formats. Use of currently available computer programs can reduce the time required, ensure correct calculations, and produce results that comply with DOD guidance. A word of caution: results from computer runs are only as good as the data input -- valid data must be used.

a. PC ECONPACK software is an economic analysis computer package available throughout USACE. PC ECONPACK incorporates economic analysis calculations, documentation, and reporting capabilities to allow the non-economist to prepare complete and properly documented economic analyses. These programs can be obtained from HQUSACE (CEMP MC). Appendix E provides a sample computer output.

b. Examples of economic analysis reports generated by ECONPACK Appendix E shows examples of typical economic analysis reports as generated by ECONPACK. If an economic analysis is not generated on ECONPACK, results should be reported as described above. Formats for presenting results should be as shown in the reports for the examples of appendix E.

EXAMPLES

1. ***Example One.*** The following is an example of a Class VI(b) system Economic Analysis. Please note that the Class VI(b) system Economic Analysis requires only net present value calculations. Thus, there are no cost sensitivity tests, SIR, DPP, etc.

PROJECT EXECUTIVE SUMMARY

Project Title: WORKGROUP INSTALLATION

Period of Analysis: 6 Years

Start Year: 1999 Project

Project Objective: To provide electronic file processing and sharing capabilities, as well as laser printing capabilities to 50 employees. Every employee should have the ability to exchange and process electronic data at any time, including software applications. Employees should be able to continue working while waiting for documents to print, and the wait time for a job should be no more than 3 minutes.

Assumptions:

1. The start year is 1999.
2. The real discount rate used in this analysis is 2.4%.
3. Lead time (period extending from the expenditure of funds to the completion of installation) is one year.
4. The economic life of the alternatives is five years; thus, there are no residual values associated with the alternatives.
5. Printer use is expected to remain constant over the period of analysis.
6. Personnel and workload are expected to remain constant over the period of analysis.
7. Software application upgrades are required every two years.
8. All costs were derived and estimated in 1999 dollars.
9. All costs were included in the analysis to represent the total outlays and total net present values of each alternative.
10. PCs and Printers will have a 1-year maintenance-free guarantee.
11. Due to the minimum hardware specifications of the required software, the existing PCs cannot be used or upgraded and will be excessed.

Alternatives Considered:

1. *Status Quo:* Currently, all 50 employees must share 10 stand-alone PCs (8086, 64K, CGA monitor) and 7 high quality dot-matrix printers (4ppm) between themselves. The printers are connected to 7 other PCs which are used as print servers. After the employees perform their tasks using paper and pencil, they must then transfer the data into electronic format via a PC. After saving their files on floppy disk, the employees walk over to a printer, insert the disks into a PC connected to a printer, and print out their files. Employees frequently wait to use these limited resources for extended periods of time, and this alternative does not satisfy any of the stated criteria. The Status Quo is not feasible.

2. *SNEAKER-NET SOLUTION:* Under this alternative, every employee in the division would be equipped with a stand-alone PC. Each PC would have Windows and DOS pre-installed, and the software applications would include a word processor, spreadsheet, and graphics package. There would also be 10 laser printers for the entire division, where each group of employees would be connected to a laser printer via laserboard installation. Although the file exchange would occur via manual transport of floppy disks (i.e., walking over to another PC with the disk -- hence the name "sneaker-net", all 50 employees would have electronic data processing and exchange capability, as well as unlimited laser printing access.

3. *WORKGROUP SOLUTION:* This alternative provides 5 unmanaged hubs for small workgroups of 10 employees each. Under this option, the division would be equipped with 50 stand-alone PCs, and every workgroup would be connected through a 12-port hub, twisted-pair Ethernet system. Every PC would come with Windows and DOS, and the software applications would include a word processor, spreadsheet, and graphics package. In addition, 2 laser printers would be connected to each hub (10 total printers), and each workgroup would have access to either printer. This system would enable file sharing and updating to occur electronically for each workgroup, where every employee would have unlimited laser printing access.

Results and Recommendations:

€ *Net Present Value Results*

Alternative Name:	NPV
1. € Sneaker-Net" Solution	$1,205,715
2. Workgroup Solution	$1,253,560

€ *Non-Monetary Benefits*

Alternative 2, the Workgroup Solution, would provide instantaneous data and file exchange for each division workgroup. There would be virtually no wait time involved, and the amount of floppy disks floating around among the work stations would be reduced as well. This equates to a reduction in processing time, enabling the employee to complete tasks in an efficient and effective manner.

The Workgoup Solution also provides for easy upgradeability. The division is exploring the idea of managing its files in a database due to ever-decreasing file cabinet space, and the Workgroup Solution alternative makes this possible simply by loading software on to the system. Similarly, scheduling and communication for the employees can be made available with minimal effort involved. The Workgroup Solution has the potential to provide the division with full automated capabilities.

€ *Recommendation*

Costs and benefits were analyzed over a 6-year period. Annual costs were discounted at a 2.4 percent rate, and then totalled to arrive at a net present value (NPV). The least-cost alternative is the "Sneaker-Net Solution" (Alternative 1), with a NPV of $1.205M, while the Workgroup Solution

(Alternative 2) has a NPV of $1.253M.

Based on the results of the analysis, the Workgroup Solution (Alternative 2) is recommended for funding to meet the requirements. Although it is not the least-cost option, the Workgroup Solution is only $48K more in NPV terms. Additionally, the Workgroup Solution alternative would enable employees to update and transfer files in a more efficient and effective manner. This ultimately results in increased productivity and a higher quality product. The Workgroup Solution would also provide upgradeability to full automation with very little effort.

Action Officer: Mal E. Bu, Project Manager, (123) 456-7890
Organization: Los Angeles District

*** Note:** Normally, the alternative with the lowest NPV would be the alternative that is recommended for funding. However, there may be other considerations (as demonstrated in this example) that weigh into the decision.

LIFE CYCLE COST REPORT

Calculation of Discount Factors:

CALCULATION OF DISCOUNT FACTORS WHEN i = 2.4%, USING MIDDLE-OF-YEAR DISCOUNTING CONVENTION		
Year n	$1/(1+i)^{n-.5}$ =	Discount Factor
1	$1/(1.024)^{1-.5}$	.988
2	$1/(1.024)^{2-.5}$	.965
3	$1/(1.024)^{3-.5}$	.942
4	$1/(1.024)^{4-.5}$	.920
5	$1/(1.024)^{5-.5}$	.899
6	$1/(1.024)^{6-.5}$	.878

*** Note:** i = the 6-year, real discount rate (remember to use the real discount rate when using constant dollars), and a middle-of-year discounting convention is used because all costs are spread evenly over the year; however, if you are particularly averse to performing mathematical calculations, you can simply turn to Appendix C and use the discount factors listed in the "Middle Of Year Discount Factors" table.

Life Cycle Cost Reports:

ALTERNATIVE 1: SNEAKER-NET SOLUTION								
Year	Cost Elements (actual $s)					Total Annual Outlays	Disc. Factor	Net Present Value of Annual Outlays
	Hard-ware	Soft-ware	Install-ation	Maint. Support	Supplies			
1999	167,450	37,500	30,000			234,950	.988	232,130
2000				150,000	26,850	176,850	.965	170,660
2001		7,500		190,000	26,850	224,350	.942	211,340
2002				190,000	26,850	216,850	.920	199,500
2003		7,500		190,000	26,850	224,350	.899	201,690
2004				190,000	26,850	216,850	.878	190,395

ALTERNATIVE 2: WORKGROUP SOLUTION								
Year	Cost Elements (actual $s)					Total Annual Outlays	Disc. Factor	Net Present Value of Annual Outlays
	Hard-ware	Soft-ware	Install-ation	Maint. Support	Supplies			
1999	186,600	45,500	35,000			267,100	.988	263,895
2000				152,500	26,850	179,350	.965	173,075
2001		7,500		193,750	26,850	228,100	.942	214,895
2002				193,750	26,850	220,600	.920	202,950
2003		7,500		193,750	26,850	228,100	.899	205,060
2004				193,750	26,850	220,600	.878	193,685
					Total Outlays =	1,343,850	**Total NPV =**	**1,253,560**

Source and Derivation of Costs:

ALTERNATIVE 1: SNEAKER-NET SOLUTION

1. Hardware.
   A. 50 personal computer work stations (486DX2/50MHz CPU, 8 MB RAM, 340 HD, SVGA Color Monitor, extended keyboard, mouse, pre-loaded Windows and DOS) @ $1,750 per work station = $ 87,500
   Source: Based on the average of 5 GSA vendor price lists.

   B. 10 laser printers (17ppm, 600 dpi, dual bins, transparency capability, envelope, label, and front/back printing) @ $6,500 per printer = $65,000
   Source: Black Box Catalog, Feb 1998.

   C. 10 printer sharing cards (6 serial, 1 parallel input, oversized buffer) @ $700 per card = $7,000
   Source: Black Box Catalog, Feb 1998.

   D. 50 Modular adapters (1 per each workstation) @ $10.20 per adapter $510
   Source: Black Box Catalog, Feb 1998.

   E. 3,750 feet of modular cabling @$.25/ft = $940
   Source: Black Box Catalog, Feb 1998.

   F. 50 Back-up Systems (250 MB, 1 per workstation) @ $130 per system = $6,500
   Source: DataPro Catalog, Jan 1998.

   Hardware Total = $167,450

2. Software.
   A. 50 Windows software applications packages, which includes word processor, spreadsheet, and graphics capabilities @ $750 per work station = $37,500
   Source: Based on the average of 5 software vendor GSA price lists.

   B. 100 software upgrades (2 upgrades per work station) @ $150 per upgrade = $15,000
   Source: Based on the average of 5 software vendor GSA price lists.

   Software Total = $52,500

3. Installation.
   1,500 hours of labor @ $20.00/hour (Washington D.C. area estimate) = $ 30,000
   Source: Survey of 5 D.C. area hardware installation firms.

   Installation Total = $ 30,000

4. Maintenance/Support.

   A. PC Maintenance Contract: 1 year contract @ $300 per work station x 50 work stations (includes all parts and labor, on call 5 days a week) = $ 15,000/yr
   Source: Historical vendor contracts for maintenance.

   B. Printer Maintenance Contract: 1 year contract (includes all parts and labor, on call 5 days a week) @ $2,500/printer/year x 10 printers = $ 25,000/yr
   Source: Average of 5 current vendor maintenance contracts for laser printers.

   C. Support: 1 year contract (includes PC and printer trouble-shooting, hardware and software support, 40 hours a week) = $150,000/yr
   Source: Survey of 5 vendor support contracts for the Washington, D.C. area.

   Maint./Suppt Total **$190,000/yr**

5. Supplies.

   A. 2 cases of paper (10 reams per case) per month per printer x 10 printers x 12 months @ $30 per case = $7,200/yr
   Source: Info World, 21 Mar 1998.

   B. 1 toner cartridge per printer per month x 10 printers x 12 months @$150/cartridge = $18,000/yr
   Source: Historical supply records, HP GSA price list, 1998.

   C. 2 boxes of 3.5" floppy disks (10 disks per box, MFD-2HD) per work station per year x 50 work stations @ 10.50/box = $1,050/yr
   Source: 3M GSA Price List, 1998.

   D. 4 back-up tapes (DC 2120) per work station per year x 50 workstations @ $3/tape = $600/yr
   Source: 3M GSA Price List, 1998.

   Supplies Total = **$ 26,850/yr**

ALTERNATIVE 2: WORKGROUP SOLUTION

1. Hardware.
   A. 50 personal computer work stations (486DX2/50MHz CPU, 8 MB RAM, 340 HD, SVGA Color Monitor, extended keyboard, mouse, pre-loaded Windows and DOS) @ $1,750 per work station = $87,500
   Source: Based on the average of 5 GSA vendor price lists.

   B. 10 laser printers (17ppm, 600 dpi, dual bins, transparency capability, envelope, label, and front/back printing) @ $6,500 per printer = $65,000
   Source: Black Box Catalog, Feb 1998.

   C. 50 Back-up Systems (250 MB, 1 per workstation) @ $130 per system = $6,500
   Source: DataPro Catalog, Jan 1998.

   D. 50 Ethernet Network cards (16-bit ISA twisted-pair) @ $120/PC = $6,000
   Source: HP GSA price list, 1998.

   E. 10 Printer Network interface cards @ 110/card = $1,100
   Source: HP GSA price list, 1998.

   F. 5 Ethernet Network Hubs (12 twisted-pair ports, supports twisted-pair cascading, full 802.3 multiport repeater) = $10,000
   Source: HP GSA price list, 1998.

   G. 5 Patch Panels = $1,500
   Source: HP GSA price list, 1998.

   H. Cabling: Includes all materials associated (RJ-45 twisted pair cables and connectors) @ $150/drop x 60 drops = $9,000
   Source: Black Box Catalog, Feb 1994.

   Hardware Total = $186,600

2. Software.
   A. 50 Windows software applications packages, which includes word processor, spreadsheet, and graphics capabilities @ $750 per work station = $37,500
   Source: Based on the average of 5 software vendor GSA price lists.

   B. 100 software upgrades (2 upgrades per work station) @ $150 per upgrade = $15,000
   Source: Based on the average of 5 software vendor GSA price lists.

   C. Workgroup operating system software @ $160 per work station x 50 work stations = $8,000
   Source: LAN Times, Feb 1998.

   Software Total = $60,500

3. Installation.
   2,000 hours of labor @$20.00/hour (Washington D.C. area estimate) = $40,000
   Source: Survey of 5 D.C. area hardware installation firms.

   Installation Total = $40,000

4. Maintenance/Support.
   A. PC Maintenance Contract: 1 year contract @ $325 per work station x 50 work stations (includes all parts and labor, on call 5 days a week) = $16,250/yr
   Source: Historical vendor contracts for maintenance.

   B. Printer Maintenance Contract: 1 year contract (includes all parts and labor, on call 5 days a week) @ $2,500/printer/year x 10 printers = $25,000/yr
   Source: Average of 5 current vendor maintenance contracts for laser printers.

   C. Support: 1 year contract (includes PC and printer trouble-shooting, hardware and software support, 40 hours a week) = $152,500/yr

   Source: Survey of 5 vendor support contracts for the Washington, D.C. area.

   Maint/Supp. Total = $193,750/yr

5. Supplies.
   A. 2 cases of paper (10 reams per case) per month per printer x 10 printers x 12 months @ $30 per case = $7,200/yr
   Source: Info World, Mar 1998.

   B. 1 toner cartridge per printer per month x 10 printers x 12 months @ $150/cartridge = $18,000/yr
   Source: HP GSA price list, 1998.

   C. 2 boxes of 3.5" floppy disks (10 disks per box, MFD-2HD) per work station per year x 50 work stations @ 10.50/box = $1,050/yr
   Source: 3M GSA price list, 1998.

   D. 4 back-up tapes (DC 2120) per work station per year x 50 workstations @ $3/tape = $600/yr
   Source: 3M GSA price list, 1998.

   Supplies Total = $26,850/yr

2. ***Example Two***. The following is an example of a Class VI(a) system Economic Analysis. In addition to the elements included in a Class VI(b) system Economic Analysis, the Class VI(a) analysis also includes a cost sensitivity analysis as well. However, because the status quo is not feasible in this example, SIR and DPP cannot be calculated. For an example using SIR, DPP, and EUAC calculations, please see appendix E.

PROJECT EXECUTIVE SUMMARY

Project Title: ULTIMA Financial Management System

Period of Analysis: 7 Years

Start Year: 1999

Project Objective: To provide Corps financial managers with a Windows interface to network analysis centers and the Corps financial management databases.

Assumptions:
1. The start year is 1999.
2. The real discount rate used in this analysis is 2.4%.
3. Lead time (period extending from the expenditure of funds to the complete deployment of the system) is two years.
4. The economic life of the alternatives is five years; thus, there are no residual values associated with the alternatives.
5. Personnel and workload are expected to remain constant over the period of analysis.
6. Software upgrades for the Commercial-Off-The-Shelf (COTS) Alternative is required in 2003.
7. All costs were derived and estimated in 1999 dollars.
8. All costs were included in the analysis to represent the total outlays and total net present values of each alternative.
9. Each package, if selected, will become the Corps standard.
10. All Corps employees have Windows installed on their computers.
11. A significant portion of the programming costs for the ULTIMA system will come from software enhancements, due to expected system expansion and capability upgrades.

Alternatives Considered:

1. *ULTIMA SYSTEM IN ADA:* The Corps would have a contractor design, implement, and maintain a financial management system called ULTIMA. Under this alternative, ULTIMA would be developed in Ada, and the government would own the code. The system would be able to interface with other information systems, as well as the various Corps databases. All enhancements, maintenance, support, and project administration would be provided by the contractor.

2. *COMMERCIAL-OFF-THE-SHELF SYSTEM:* A financial management software system would be purchased from the private sector and used as the Corps standard for financial management. The vendor's purchase price would include an unlimited site license for all Corps users. The Corps would, however, contract out to program the interfaces. A contractor would also provide all maintenance, support, and administration for the system.

3. *ULTIMA SYSTEM IN C++:* The Corps would have a private contractor design, implement, and maintain a financial management system called ULTIMA. Unlike the ULTIMA Ada alternative, however, the ULTIMA system would be developed in C++. The system would also be able to interface with other information systems, as well as the various Corps databases. All enhancements, maintenance, support, and

project administration would be provided by the contractor. The government would also own the code.

4. *STATUS QUO:* Currently, every financial management department in the Corps has its own financial management system. There are about 70 different systems in use, but none are programmed for use in a Windows operating system. Because of the recent mandate by the Corps to convert all financial systems into a Windows format and to connect to the Corps financial management databases, the Status Quo option is not feasible.

Results and Recommendations:

€ *Net Present Value Results*

Alternative Name:	NPV
1. ULTIMA in Ada	$2,246,927
2. Commercial-Off-The-Shelf	$2,591,653
3. ULTIMA in C++	$2,642,885

€ *Non-Monetary Benefits*

The primary benefit of ULTIMA is that the government would own the code. This would allow the government to make any enhancements and adjustments to the system in a quick, responsive manner. The less time spent on making changes to the system equates to less down time.

€ *Cost Sensitivity Analysis Results*

1. In the first cost sensitivity analysis test, the cost of software enhancement in the ULTIMA Ada option (Alternative 1)was varied to see if a change of rankings would result between the ULTIMA Ada option and the ULTIMA C++ alternative (Alternative 3). The results show that for C++ alternative to be ranked least cost, the software maintenance cost must be increased by more than 42.07%. Since an increase of this amount in the software maintenance cost is unlikely, however, the ULTIMA Ada option is insensitive to changes in its software maintenance cost.

2. Similarly, the second sensitivity analysis tested the ULTIMA Ada software maintenance cost to see if a change in the rankings would result between the Ada option and the COTS (Alternative 2) option. The results show that for the COTS alternative to be ranked least cost, the software maintenance cost must be increased by more than 36.62%. The ULTIMA Ada option is insensitive to changes in its software maintenance cost.

€ *Recommendation*

Costs and benefits were analyzed over a 7-year period. Annual costs were discounted at a 2.5 percent rate, and then totalled to arrive at a net present value (NPV). The least-cost alternative is the ULTIMA Ada (Alternative 1), with a NPV of $2.25M.

The ULTIMA C++ ($2.64M) and the COTS ($2.59M) options are both $400K more than the ULTIMA Ada alternative, respectively. Thus, the government would need $390K more (in present value terms, invested at 2.5%) to finance the ULTIMA C++ alternative and $340K more for the COTS alternative.

Based on the NPV and cost sensitivity test results, the least-cost alternative to meet this requirement is the ULTIMA Ada option, and is recommended for funding. Moreover, the ULTIMA Ada alternative would provide the government the added benefit of owning the code, which will result in responsive changes to the system, less down time, and unlimited government distribution.

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LIFE CYCLE COST REPORT

Calculation of Discount Factors:

CALCULATION OF DISCOUNT FACTORS WHEN i = 2.5%, USING MIDDLE-OF-YEAR DISCOUNTING CONVENTION		
Year n	$1/(1+i)^{n-.5}$ =	Discount Factor
1	$1/(1.025)^{1-.5}$	.988
2	$1/(1.025)^{2-.5}$	.964
3	$1/(1.025)^{3-.5}$	.940
4	$1/(1.025)^{4-.5}$	.917
5	$1/(1.025)^{5-.5}$	.895
6	$1/(1.025)^{6-.5}$	.873
7	$1/(1.025)^{7-.5}$	.852

*** Note:** i = the 7-year, real discount rate (remember to use the real discount rate when using constant dollars) and a middle-of-year discounting convention is used because all costs are spread evenly over the year; however, if you are particularly averse to performing mathematical calculations, you can simply turn to Appendix C and use the discount factors listed in the "Middle Of Year Discount Factors" table.

Life Cycle Cost Reports:

ALTERNATIVE 1: ULTIMA in Ada											
	Cost Elements (Actual $s)								Total Annual Outlays	Disc. Rate	NPV of Annual Outlays
Year	Software Develop.	Data Interf.	System Deploy.	Hotline Support	Software Mainten.	Software Enhance.	Database Mainten.	Project Admin.			
1999	800,000	35,000							835,000	.988	824,755
2000	200,000	35,000	150,000			37,679	12,000	4,500	439,179	.964	423,210
2001				6,500	5,300	102,542	6,000	3,200	123,542	.940	116,146
2002				6,500	5,300	102,542	6,000	3,200	123,542	.917	113,313
2003				6,500	5,300	272,753	6,000	3,200	293,753	.895	262,860
2004				6,500	5,300	272,753	6,000	3,200	293,753	.873	256,450
2005				6,500	5,300	272,753	6,000	3,200	293,753	.852	250,193
								Total Outlays =	2,402,522	**Total NPV =**	2,246,927

ALTERNATIVE 2: Commercial-Off-The-Shelf

Year	Cost Elements (Actual $s)								Total Annual Outlays	Disc. Rate	NPV of Annual Outlays
	Acquis. Cost	Data Interf.	System Deploy.	Hotline Support	Software Maint.	Software Upgrades	Database Mainten.	Project Adm.			
1999	1798000	89,000							1,887,000	.988	1,863,846
2000		47,000	260,000				12,000	4,500	323,500	.964	311,737
2001				7,530	6,250		6,000	3,200	22,980	.940	21,604
2002				7,530	6,250		6,000	3,200	22,980	.917	21,078
2003				7,530	6,250	350,000	6,000	3,200	372,980	.895	333,375
2004				7,530	6,250		6,000	3,200	22,980	.873	20,062
2005				7,530	6,250		6,000	3,200	22,980	.852	19,571
								Total Outlays =	2,675,400	**Total NPV =**	2,591,653

ALTERNATIVE 3: ULTIMA in C++

Year	Cost Elements (Actual $s)								Total Annual Outlays	Disc. Rate	NPV of Annual Outlays
	Software Develop.	Data Interf.	System Deploy.	Hotline Support	Software Mainten.	Software Enhance.	Database Mainten.	Project Adm.			
1999	950,000	42,000							992,000	.988	979,828
2000	225,000	42,000	150,000			45,677	12,000	4,500	479,177	.964	461,754
2001				6,500	5,980	115,000	6,000	3,200	136,680	.940	128,498
2002				6,500	5,980	115,000	6,000	3,200	136,680	.917	125,364
2003				6,500	5,980	340,000	6,000	3,200	361,680	.895	323,643
2004				6,500	5,980	340,000	6,000	3,200	361,680	.873	315,751
2005				6,500	5,980	340,000	6,000	3,200	361,680	.852	308,047
								Total Outlays =	2,829,577	**Total NPV =**	2,642,885

Cost Sensitivity Analysis:

1. Ada vs. C++: Software Enhancement for
ALLOWABLE CHANGE . . . . . 200.00 PERCENT
This sensitivity analysis checks for the ULTIMA C++ option (Alternative 3) to be ranked least cost as a result of changes in Ada's software maintenance cost listed below:

ALTERNATIVE	EXPENSE ITEM
1 - ULTIMA Ada	Software Enhancement
3 - ULTIMA C++	** NOTHING CHANGED **

The Ada Only Option's Software Maintenance expense item was allowed to vary from a value of 100% less than its input value to 200.00% more than its input value.

ALTERNATIVE	NET PRESENT VALUE
1 - ULTIMA Ada	$2,246,927
3 - ULTIMA C++	$2,642,885

For the C++ option to be ranked least cost, the selected expense item must be increased by more than 42.07%.

2. Ada vs. COTS: Software Enhancement for
ALLOWABLE CHANGE ..... 200.00 PERCENT
This sensitivity analysis checks for the COTS option (#2) to be ranked least cost as a result of changes in the Ada software maintenance cost listed below:

ALTERNATIVE	EXPENSE ITEM
1 - ULTIMA Ada	Software Enhancements
2 - Commercial Off-The-Shelf	** NOTHING CHANGED **

The Ada Only option's Software Maintenance expense item was allowed to vary from a value of 100% less than its input value to 200.00% more than its input value.

ALTERNATIVE	NET PRESENT VALUE
1 - ULTIMA Ada	$2,246,927
2 - Commercial Off-The-Shelf	$2,591,653

For the COTS option to be ranked least cost, the selected expense item must be increased by more than 36.62%.

Source and Derivation of Costs:

ALTERNATIVE 1: ULTIMA IN ADA

1. **Software Development.** 8 Programmers (@ $100,000/yr salary) x 15 mths = $1,000,000.

2. **Develop Data Interfaces.** Includes all work for Corps database interface capability. 1 Ada Programmer (@ 35,000/yr salary) x 2 years = $70,000.

3. **System Deployment.** Includes all loading, installation, materials, and hook-up for the Corps and other required points-of-contact. 1,000 workstations @ $150/workstation = $150,000.

4. **Hotline Support.** Flat-rate fee for limited hotline support: 3 minute max. for calls - installation problems, bugs, etc. Application features not covered.

5. **Software Maintenance.** Estimated number of hours for maintenance per year is 200. 200 x $27/hr (maint. rate) = $5,300.

6. **Software Enhancements.** Enhancements must be done to accommodate mandated functionality and Corps system expansion. Some enhancements are needed in deployment year 2000: 1 programmer @ $59,333/yr x 7.6 months = $37,679. Years 2001, 2002: 2 programmers ($59,333/yr each) x 10.37 months = $102,542. Years 2003-2005: 5 programmers ($59,333/yr each) x 11 months = $272,753.

7. **Database Maintenance.** Includes all trouble-shooting and database integration. Approx. 480 hrs. @ $25/hr = $12,000 for 1st year. Subsequent years: 240 hrs. @ $25/hr = $6,000.

8. **Project Administration.** Includes day-to-day administration of the system. Approx. 300 hours @ $15/hr = $4,500 for the 1st year. Subsequent years: 213 hours @ $15/hr = $3,200.

SOURCE: All Costs and Schedules taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

ALTERNATIVE 2: COMMERCIAL-OFF-THE-SHELF

1. **Acquisition Cost for FundCruncher, Plus.** Includes an unlimited site license for Corps use. The government does not own the code. $1,798,000.
   SOURCE: Average of 5 1999-2000 GSA price lists.

2. Data Interfaces. Includes all work for Corps database interface capability. 2 programmers @$44,500/yr each x 18.3 months = $136,000.
   SOURCE: Taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

3. **System Deployment.** Includes all loading, installation, materials, and hook-up for the Corps and other required points-of-contact. Also requires extra peripherals. 1000 workstations @ $260/workstation = $260,000. Deployment will be completed in 12 months.
   SOURCE: Taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

4. **Hotline Support.** Flat-rate fee for hotline support: No time limit for calls - installation problems, bugs, etc. Application features covered.
   SOURCE: MacroFirm's 1999-2000 GSA price list estimate.

5. **Software Maintenance.** Estimate number of hours per year is 196. $27/hr x 196 = $5,300.
   SOURCE: Taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

6. **Software Upgrades.** Upgrades needed to accommodate system expansion. Scheduled release date 2003. Purchase price = $350,000.
   SOURCE: MacroFirm's 1999-2000 GSA price list estimate.

7. **Database Maintenance.** Includes all trouble-shooting and database integration. Approx. 480 hrs. @ $25/hr = $12,000 for 1st year. Subsequent years: 240 hrs. @ $25/hr = $6,000.
   SOURCE: Taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

8. **Project Administration.** Includes day-to-day administration of the system. Approx. 300 hours @ $15/hr = $4,500 for the 1st year. Subsequent years: 213 hours @ $15/hr = $3,200.
   SOURCE: Taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.

ALTERNATIVE 3: ULTIMA IN C++

1. **Software Development.** 8 C++ Programmers (@ $118,750,/yr salary) x 14.8 mths = $1,175,000.

2. **Data Interfaces.** Includes all work for Corps database interface capability. 1 C++ Programmer (@ $42,000/yr salary) x 24 months = $84,000.

3. **System Deployment.** Includes all loading, installation, materials, and hook-up for the Corps and other required points-of-contact. 1000 workstations @ $150/workstation = $150,000.

4. **Hotline Support.** Flat-rate fee for limited hotline support: 3 minute max. for calls - installation problems, bugs, etc. Application features not covered.

5. **Software Maintenance.** Estimated number of hours for maintenance per year is 221. 221 x $27/hr (maint. rate) = $5,980.

6. **Software Enhancements.** Enhancements must be done to accommodate mandated functionality and Corps system expansion. Some enhancements are needed in deployment year 2000: 1 programmer @ $59,333/yr x 9.2 months = $45,677. Years 2001, 2002: 2 programmers ($59,333/yr each) x 11.6 months = $115,000. Years 2003-2005: 6 programmers ($59,333/yr each) x 11.5 months = $340,000.

7. **Database Maintenance.** Includes all trouble-shooting and database integration. Approx. 480 hrs. @ $25/hr = $12,000 for 1st year. Subsequent years: 240 hrs. @ $25/hr = $6,000.

8. **Project Administration.** Includes day-to-day administration of the system. Approx. 300 hours @ $15/hr = $4,500 for the 1st year. Subsequent years: 213 hours @ $15/hr = $3,200.

   SOURCE: All Costs and Schedules taken from an average of 3 contractor estimates: Divine Software Developers, Technologies, Inc., and Systems-R-Us.